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Spectrophotometric characterization of organic memristive devices

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ABSTRACT

Realizing element able to mimic some features of the human brain is a challenging perspective. The concept of organic devices, based on conductive polymers, is attracting significant interest being generally bio-compatible, able to work in liquid phase, with low bias voltage ranges. Organic memri-stive devices have demonstrated the capability of mimicking some properties of biological synapsis. Moreover, memristive devices based on polyaniline (PANI) have been used as artificial synapsis in the hardware of a single layer perceptron. In the perspective of a multi-layered perceptron, a fundamental step is the knowledge of the conductive state of each single memristor. The electrochromicity of PANI endows us to developed a non-invasive and precise method to solve this problem; in fact, PANI memristor's state (induced by the voltage biasing) can be monitored measuring its optical features variation by means of a spectrophotometer. The latter, thanks to its high accuracy, allows distinguishing minimal color variation at a micrometric distance and, without lowering its precision, can measure areas of 7×60 cm^2 in a single scan and reach, in several scans, a total area of 120×140 cm^2. Therefore, in future works we will extend the here proposed method in order to get, in a single scan, contact-less measurement and information about the state of each single PANI memristor belonging to a multi-layered perceptron.

1. Introduction

Since 2008 [1], year of the first report on the realized memristor, we can observe a growing interest to this element that can be considered as a synapse analogue in electronic circuits. By definition the latter can vary its resistance depending on the charge passed through it and can keep memory of its previous conductive states [2]. Thanks to these features memristors can be used as non-volatile memories and as logic gate, being capable of performing logical operations [3,4]. The most of reported memristive devices use metal oxides as an active layers [5]. However, there are several works, where organic memristors were reported [6].

Organic memristors have several advantages, with respect to devices based on inorganic materials, such as higher flexibility, easy and low costs deposition methods and a low voltage working range. In particular, memristors based on polyaniline (PANI), designed and realized specifically for adaptive networks, stood out among others, demonstrating classical memristive features, such as hysteresis loop in current vs voltage characteristic and also synapse mimicking [7] properties and learning capabilities [8]. Finally, using PANI based memristors, it was constructed a single layer (or elementary) perceptron [9]. The latter is the simplest form of a complex artificial neural network (ANN), based on adaptive links [10]. Similar results were also reported on cross-bar system, based on inorganic memristive devices [5]. Single layer perceptron can solve elementary anthropomorphic tasks such as: input classification, image and speech recognition. In such system, memristive devices work as synapsis, capable to vary their weight functions. Output signals are summed in a neuron, realized by a simple circuit based on operational amplifiers. In particular, the realized perceptron was trained in a way that, after learning, it was able to perform NAND or NOR logic functions. The training (correction of the weight functions, performed by memristors) was done analysing the actual output signal value at a certain combination of inputs and comparing it with a theoretical value of the output for a particular logic element. When the error was equal to zero, no action was required while, if the error was negative, the link was reinforced by external action or inhibited, if the error was positive. It is important to note that, in the case of a single layer perceptron, we need to know only the configuration of the inputs and corresponding

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